2. HISTORY OF APPLIED MECHANICS CABINET AND MECHANISMS COLLECTION

2.1. The first models and start of collection

The scientific and technical revolution which began in the 18th century, led to society becoming aware of the need for training engineers. The first such school was École Polytechnique, founded in 1794 in Paris by G. Monge. In the 19th century, high technical institution and engineering universities began to appear. In Russia the first such institution was the Institute of Corps Engineers of Communications (today – Petersburg University of Transport) opened in 1810 in St. Petersburg. A. Betancourt took great part in its establishment.

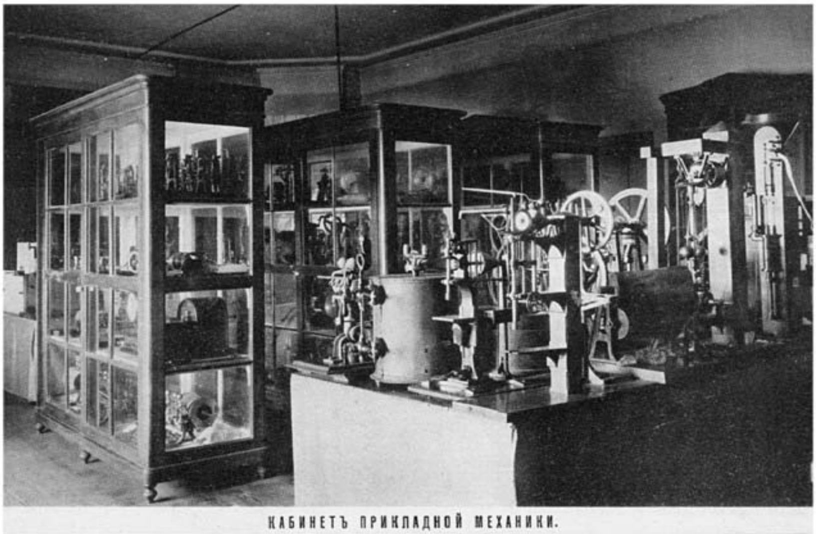

Fig. 2.1: A cabinet of “Applied mechanics” at the 19th beginning of century (the photo from museum of BMSTU)

Naturally, physical models of machines and mechanisms were accepted and effective means of engineering education. All major universities and technical institutes had significant collections of such models. Collecting, designing and manufacturing of the models of machines and mechanisms were practiced by A. Betancourt (Royal Cabinet in Spain in the period 1791–1808), J.F. Redtenbacher (Polytechnic Institute in Karlsruhe in the period 1840–1863), J. Schröder (Polytechnic Institute in Darmstadt), F. Reuleaux (Berlin Higher Technical College during the period 1879–1905), F. Orlov (Moscow University and the Imperial Moscow Technical Secondary School during the period 1872–1892), I. Rachmaninoff (Kiev University during the period 1853–1883), V. Ishmenitsky (Kharkov University during the period 1872–1882) and many other scientists. The largest collection of kinematic models (more than 800) was collected by

F. Reuleaux. This collection was considered to be ideal for technical schools in Germany and other countries [40–42]. Unfortunately, most of the collection was lost in 1945, during the bombing raids.
In Russia many of the college and university collections were lost in the 1930s–1970s a misunderstanding of the role of the old technical solutions in the training of students. Besides, due disregard of the Soviet officialdom to the technical social history, shîuld also be noted. For this reason to difficulty appeared in distributing of the collections and there was a lack of resources to keep them in decent condition. Some universities could not keep the old models, but also did not replenish their collections with new models. One of the world's largest collections of models is a collection at the Bauman University TMM Department. At present, the collection comprises more than 600 models.

Fig. 2.2: The first models of a cabinet of applied mechanics

A cabinet of mechanisms at the Department of Applied Mechanics (Fig. 2.1) was established in the mid-19th century. The collection consisted of models bought in Germany from the collections of J. Redtenbacher, J. Schröder and F. Reuleaux. Some models of the collection date back to the years 1861–1862 (Fig. 2.2). The first model was the original orthogonal spatial gear transmission. Input wheel of the transfer is a flat wheel on the front of which is only one tooth, made like Archimedes spiral. The inscription "Ivan Naumov, 1861" was engraved on the model. The second model was centrifugal regulator with an inertial element as a massive ring. On the bases of a model tablet was the inscription "Pavel Ivanov, 1862". These models visually coincide with the drawings catalogue [43], although they have small design differences. There are two sources from which these models could have reached the collection of the Cabinet of Applied Mechanics. Either they were bought in Germany (and the engraved names show people financing their purchase), or they were produced in the workrooms of

IMTS from the drawings catalogue [43]. Unfortunately, most of the archives of IMTS were destroyed during the Second World War and, therefore, it is impossible to find documents substantiating or disproving these assumptions. We can assume that Yershov established his collection sometime after 1843, when he began to teach practical mechanics and descriptive geometry in the senior class of the Moscow 3rd gymnasium, opened in 1839. Dates on the saved models belong to the period of the work of Ershov at the IMTS. It suggests that the Redtenbacher model was also bought the years of the work of Yershov, and the Cabinet of Applied Mechanics was purchased in the mid-19th century and included more than one hundred models.


Fig. 2.3: Cases with Reuleaux's models which were saved in the collection of BMSTU

In 1872, Fiodor Orlov was head of the Department of Applied Mechanics on the appointment of the Council of IMTS. During his mission in 1870–1872, he was impressed by the methods of models demonstration used in the teachings of Reuleaux. When he returned to IMTS he paid great attention to the Cabinet of Applied Mechanics, and broadened and systematized the collection of mechanisms. He took part in the creation of Cabinets of Applied Mechanics in most universities of Russia. The IMTS collection at that time was enriched with models created by Reuleaux and manufactured in Berlin in G. Voigt's workrooms. Figure 2.3 shows the cupboards from the Cabinet of Applied Mechanics with the models of Reuleaux, which have remained in the Bauman University collection until now. Among the models of the collections were those developed by Orlov and constructed in IMTS workrooms. Unfortunately, these models cannot be found.

2.2. Chebyshev's mechanisms

Pafnuty L'vovich Chebyshev was born in 1821 in the village of Okatovo in the Kaluga province. His primary education at home from the family. In 1837 he entered the faculty of philosophy of Moscow University, from where he graduated in 1841. In 1843 he passed examination for a master's degree of mathematics, and in 1846 he defended a thesis on "Experiment of the elemental analysis of probability theory". In 1847 he moved to St. Petersburg and went to work in a military academy at St. Petersburg. In 1849 Chebyshev defended a thesis for the doctor's degree of mathematics and astronomy on the theme "Theory of congruences" and two years later he was elected a extraordinary professor of Petersburg University. In 1853, Chebyshev was elected an adjunct professor, and ordinary academician of Petersburg Academy of Science of applied mathematics in 1859. He began teaching by lecturing on practical mechanics, the interest of which had an impact on his mathematical work. At different times Chebyshev taught courses of higher algebra, analytical geometry, number theory, single integral and probability theory. He created a famous mathematical school, which included outstanding mathematics A.M. Lyapunov, A.A. Markov, S.N. Bernshtein, etc. The theory of the best approximation of the functions by "Chebyshev polynomials" was born thanks to his passion for practical tasks. In 1852 in the Worldwide Exhibition in Paris he drew attention to the spotty wear of the rod of Watt's steam engine.

The article "About parallelograms" was where the first challenge of the parameter optimization of mechanisms was solved. Chebyshev died on November 26, 1894 from heart attack [44].

Linkages have been in to use in Europe since about the 12th century. During 12th–17th centuries their development progressed very slowly as the process of manufacturing joints was laborious. The establishment of precise prismatic pairs was complex, for example, for guides of steam engines cylinders. Therefore since the mid-18th century various constructions of linkages for the transformation of the linear motion to the rotary motion of a body were developed mainly empirically. The development of these mechanisms was not only the goal of the mechanism "for saving fuel and the strength of the machine", patent rights, specifically their circumvention played a substantial role too. There are well-known steam engines of Papin (1690), Savary (1698), Newcomen (1712), Leupold (1724). The first Russian steam engine was that of the Russian engineer Ivan Polzunov constructed in Altai (1766).

At the time when Chebyshev attended to this issue, the most sophisticated machines had been Watt's. To convert the rectilinear movement to rotary or to a swinging movement, Watt created several options of mechanisms, including empirically, by "trial and error method", two linkages (Figs. 2.4 and 2.5). One called reduced parallelogram was easier, but provided less accuracy of reproduction of linear motion, the second – full Watt's parallelogram, was more complicated, but also more accurate.

As Chebyshev wrote [46]: "Rules follow Watt, as a parallelogram device, and could serve as a guide for practice only until it met the need to change its shape. With the change of the form of mechanism new regulations were required". With regard to the rules of Watt, French engineer and mathematician Bour wrote that they "were created for purely secondary benefits, while the matter was of principled importance: to an extent possible to reduce the deviation. Properly speaking, it was very difficult to start the issue, which explains why it remained intact until the work of Chebyshev" [50].

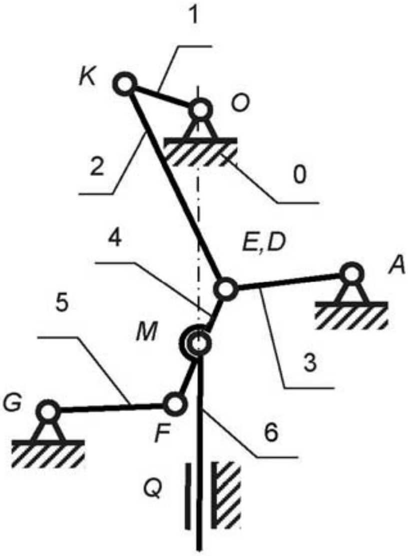

Fig. 2.4: Straight-line mechanism with reduced parallelogram Watt (Q-10)

Several works of Chebyshev were devoted to the research of parallelograms [45–49], one article written in 1869 deserves special attention [48]. In this work, Chebyshev used the series decomposition method and found a variant of assemblage of Watt's parallelogram and the ratio of the lengths, its links providing minimal deviation linearity of the trajectory of the anchorage point of a piston at the desired site. However, we must say that in Chebyshev's mechanism, in contrast to Watt's parallelogram, only one point of the mechanism moves in a straight lines. This is due to the fact that in on effort to improve the accuracy of the linear motion, Chebyshev stepped back from the ratio of lengths of the links of the parallelogram mechanism (Fig. 2.6).

In addition, Chebyshev proposed his version of the straight-line mechanism for reproduction of linear motion, which is known as the "Approximate straight-line generating mechanism of Chebyshev". In the Bauman University collection there are two models of this mechanism. The first is ligneous (Fig. 2.7, right) and was produced in the IMTS workrooms. Second (Fig. 2.7, left) is part of a collection of Reuleaux's mechanisms and was produced in Berlin in the workrooms of G. Voigt. In the collection of mechanisms of the Department of TMM, there are several models with Chebyshev and Watt's parallelograms.

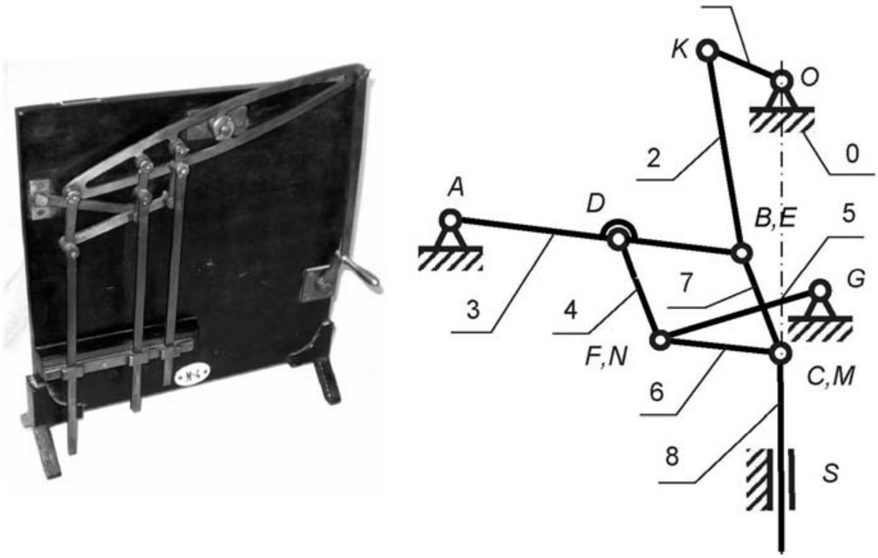

Fig. 2.5: Straight-line mechanism with a full Watt's parallelogram (M-4)

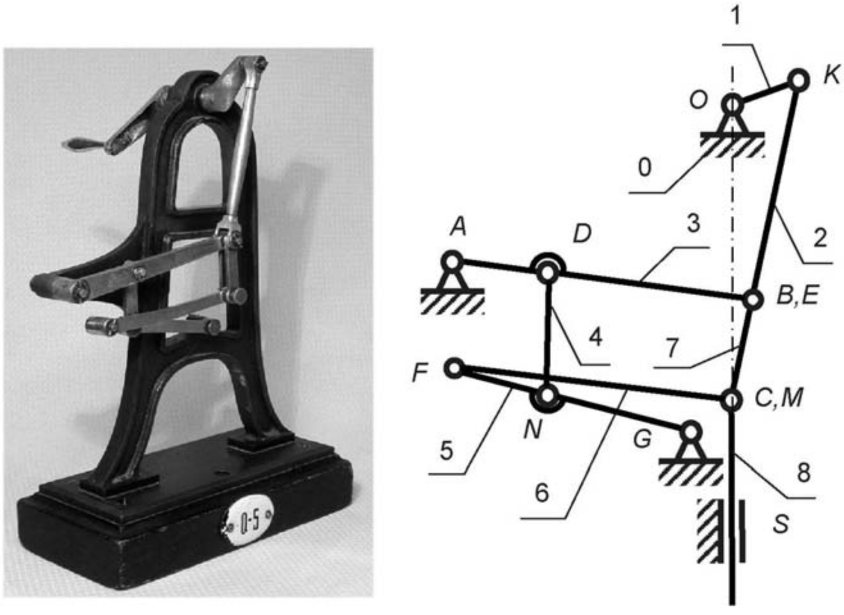

Fig. 2.6: Chebyshev's straight-line mechanism (Q-5)

Fig. 2.7: Models of "Chebyshev's priamilo" – straight-line mechanism

In his article [49], Chebyshev found ways to reach the largest, and the desired approximations to linear motion and, in fact, proposed a new, original system for a steam engine. This machine, in the view of some Russian naval engineers, could be better and more economical than the steam engines of Penn and Cave, because it would combine movement in a straight line with a continuous rotary motion; a part of the parallelogram replaced a con-rod, thus transmission of the piston's movement to the shaft was immediately achieved. Chebyshev's steam engine was single-cylinder vertical. The stock of the piston of the cylinder joined with the shaft. A hand wheel was placed there. It reduced unevenness of rotation. Rotation of the shaft was provided by an articulate parallelogram. Chebyshev's steam engine, its model and kinematic scheme of mechanism are shown in Fig. 2.8.

Naval engineers appreciated the quality of Chebyshev's steam engine. Indeed, one of them asserted that "it is enough to look at the five main systems (of steam engines), to be sure how much the steam engine with Chebyshev's mechanism can complete with every of them in its simplicity" [44]. Among other machines of the same kind, Chebyshev's steam engine, in his view, had the following advantages:

1. The easiest way of transmission is more profitable, in some respects, than in trunk cars and in cars with tilting cylinders because, without a trunk and tilting cylinder, we lead steam to the cylinder using common suitable solutions. We do not limit it to narrow corridors (as in a tilting cylinder), and cool it (such as in a car with a trunk).
2. Cost-saving of steam is possible because the system admits to leading superfine ways to cut steam, without mach effort, as in the machine with a tilting cylinder.
3. Manufacturing a cylinder for the machine should be cheaper than a trunk cylinder and tilting.
4. Changes (deformation) of the hull in the car cannot have significant influence on it because the piston rod is not led by a slide, and is directed by a parallelogram.
5. Compactness of the machine when its parts are well-located, should be the same as

in tilting cylinders and more profitable than the machines of all other systems, thus the machine of such a system should be very beneficial to the vessel.

6. It is hoped that the machine with Chebyshev's mechanism will be very cheap".

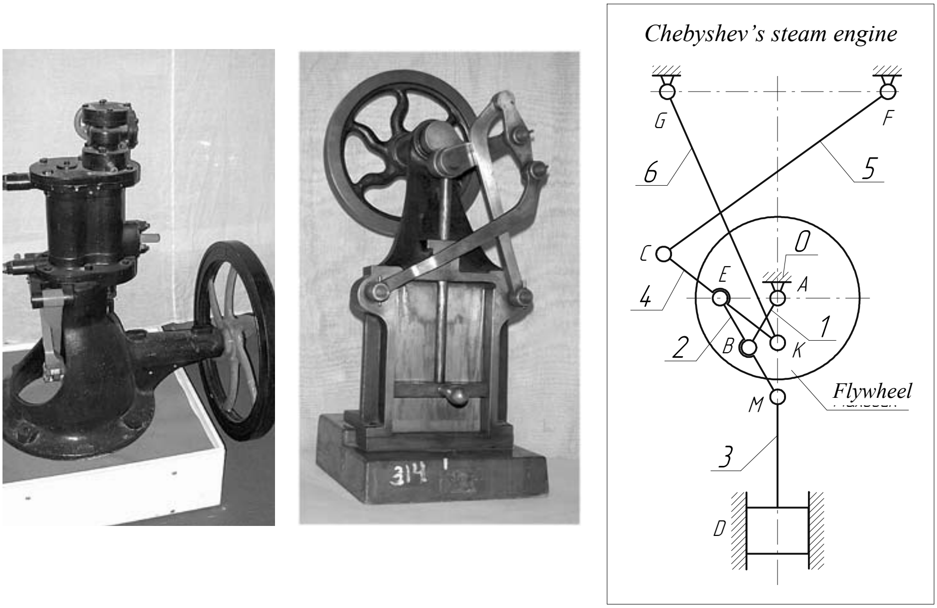

Fig. 2.8: Chebyshev's steam engine, its model and the structure chart of the mechanism

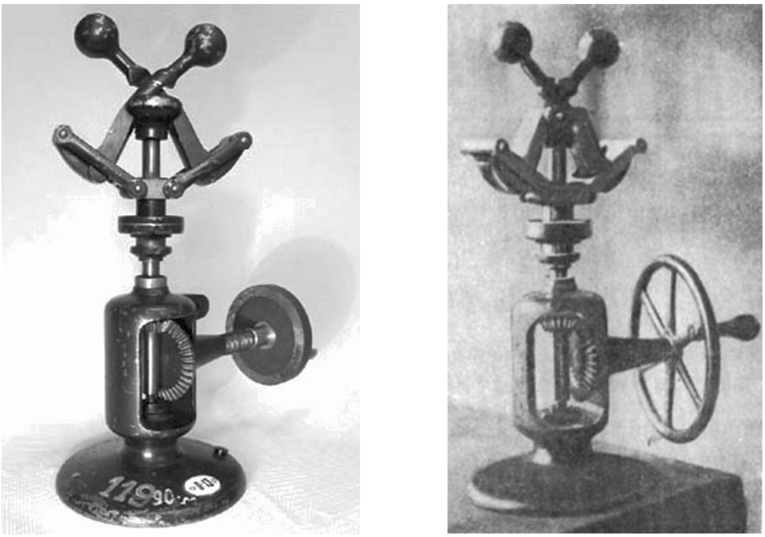

Fig. 2.9: Cebyshev's inertia governor

Chebyshev's steam engine was exhibited at the World Fair in Philadelphia in 1876. It was established and tested in the High Technical School in Moscow. This test showed that the use of Chebyshev's parallelogram is possible, though it turned out that further improvements necessary to achieve quiet and stable running. At present it is kept in the museum of Bauman University.

One of the six models of centrifugal regulators stored in the collection of the Cabinet of Mechanisms of the TMM Department, was calculated and designed by Chebyshev. In Fig. 2.9 the left photo shows this model; right – photo of a similar model from the article about mechanisms, established by Chebyshev [51]. One distinctive feature of the regulator is a complex configuration of weighted levers. This design provides a significant moment of inertia of goods and their balance: the static moment of the top of the lever become balanced by the moment of its low part. In this design inertial force doesn't overcome the weight of the goods and the sensitivity of the regulator to change the angular velocity is higher than in other construction regulators.

In total, Chebyshev developed over 80 mechanisms and devices, among them the plantigrade machine, gravity chair, rowing mechanism, inertia governor or centrifugal regulator, calculating machine. Models of these mechanisms are stored in the Polytechnic Museum, BMSTU, Moscow State University, University of St. Petersburg and also in several foreign museums.

2.3. Demonstration models of N. Joukovsky

Professor N. Joukovsky was not only an outstanding mathematician and technician but also a remarkable engineer. It has played an essential role in the history of the "Applied Mechanics" Department. He was on friendly terms with Professor F. Orlov and highly estimated his course on applied mechanics [11]. In 1895 he invited the young engineer N. Mertsalov to the post of senior lecturer and curator of the applied mechanics's cabinet. He was the teacher of Professor L. Smirnov. The high level of the courses "Analytical Mechanics" [10] and "Theoretical Mechanics" [9] read by him allowed an increase in the theoretical level of applied mechanics.

Undoubtedly, the basis of the works of N. Joukovsky have been connected with problems of aeromechanics, aeronautics and hydromechanics. However, some of his works are devoted to problems of applied mechanics, including the theory of regulation, dynamics of a kinematic circuit with one degree of freedom [52]. The course "The applied mechanics" which he read in the Moscow Practical Academy of Commercial Sciences, published by lithographic in 1901, was kept by a student of IMTS, V. Vladimirov [53].

It is known that in the mechanics course N. Joukovsky widely used demonstration models. However, at present we have only three models. These are a gyroscope on a gimbals suspension (Fig. 2.10), an example of the proof of the existence of non-sliding arches (Fig. 2.11), and a device for the proof of sliding of an extensible belt (Fig. 2.12).

Fig. 2.10: Model of a gyroscope on a gimbal suspension

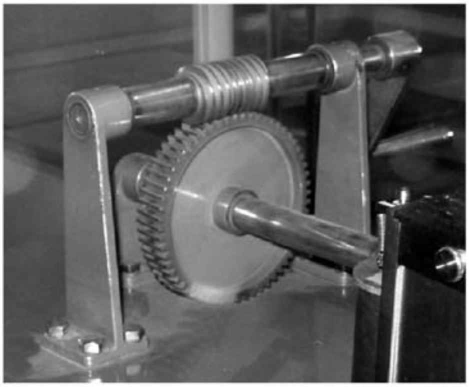

Fig. 2.11: Model for the proof of existence of non-sliding arches

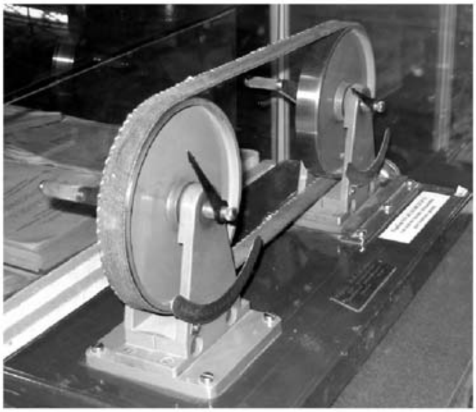

Fig. 2.12: The device for the proof of sliding of an extensible belt

2.4. Further accumulation of the collection by Professor L. Smirnov

From 1898 to 1929, the Applied Mechanics Department was headed by N. Mertsalov. We do not have any information concerning Mertsalov's contribution to the development of the collection of mechanisms. There are photographs of two Reuleaux-Voigt models and a wooden Chebyshev straight-line mechanism model in his book [17]. It is mentioned that the last one was manufactured in the department. Mechanisms of rotary machines are described in detail in the book. Engagements used in these mechanisms are illustrated. It can be assumed that when Mertsalov's book was published there were no Schröder models (Fig. 2.13), which were intended for demonstration of these engagements, in the collection yet. They were evidently purchased in Germany either when Mertsalov headed the department, or later.

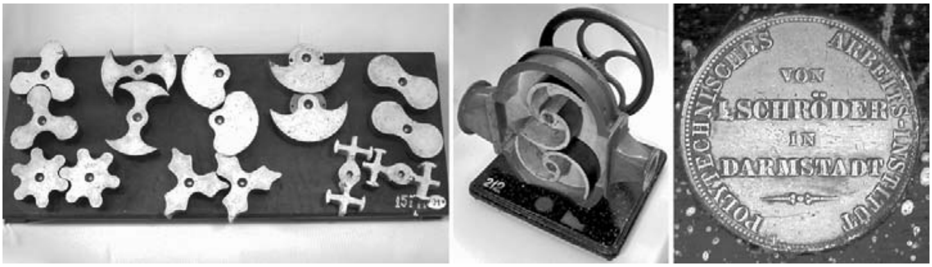

Fig. 2.13: Schröder's model for demonstration of the gearings used in a rotatory blower

Mertsalov had not only extensive theoretical knowledge but also practical skills in operating mechanisms and machines because when he was young he was a mechanical engineer at factories in Russia and Germany. He paid much attention to the collections of mechanisms of the Applied Mechanics laboratories of Moscow University and IMTS–MHTS. At that time, many models were developed at the TMM department and then manufactured in the School's workshops.

Since 1929 the department was headed by L. Smirnov (1929–1948). Under his direction, the collection of mechanisms continued to be enriched with new models, the majority of the models being developed by members of the department. The most significant contribution was made by L. Reshetov. On Smirnov's initiative, he was engaged in designing and making of gearings and cam mechanisms and increased the collection with new items (see Chapter 3).

Some mechanisms were designed by Smirnov in person. In our opinion, the "harmonizer" is the most interesting of them. The device was meant for synthesis of a function by given values of Fourier series coefficients. The idea of its creation apparently resulted from Smirnov's work concerning steam engine mechanics. Indeed, the moment of forces acting on a piston reduced to the shaft of a crank can be represented by the function shown in Fig. 2.14. The large extent of the nonzero load section is its characteristic feature. It is proved that such a function can be approximated by six Fourier series harmonics with adequate accuracy Fig. 2.14 (curve 1) – by three

terms with odd and three terms with even coefficients of the series. Amplitudes are parameters of these harmonics. They can be easily computed with the help of certain approximate formulas. Undoubtedly, to check whether the synthesized function converges to the given function two more harmonics were to be calculated (an approximate formula allows the computing of 12 terms of Fourier series – Fig. 2.14, curve 2).

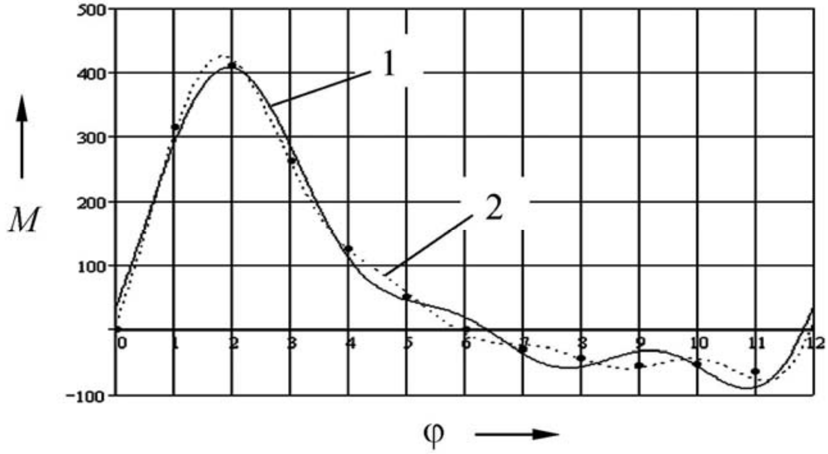

Fig. 2.14: Example of a reduced moment approximation by Fourier's row

Thus, the scientific interests of L. Smirnov agreed with important trends of the development of mechanics during the first half of the 20th century – with the development of mechanical calculators and mathematical equipment and tools (planimeters, calculators, analyzers, etc.) The harmonizer (Figs. 2.15, 2.16) designed by L. Smirnov and manufactured in BMSTU in 1934–1945 also belongs to such mechanisms. Two copies of the mechanism have survived: the first one is kept at the BMSTU museum, the other one, at the TMM department mechanism laboratory.

There are various designs of devices meant for synthesis of a function by its given values. Some of them are considered in [53]. Smirnov's "harmonizer" is intended for the approximate synthesis of a given periodic harmonic function by eight values of amplitudes of corresponding harmonic series terms computed by applying approximate formulas. The result is a complex polyharmonic curve that approximates the given function.

The "harmonizer" consists of eight controlled amplitude sine-mechanisms. On the left part of Fig. 2.15 one can see four mechanisms that describe various amplitude sine-curves. Correspondingly, on the right there are four mechanisms that describe various amplitude cosine-curves. Output sliders of each of the mechanisms through a system of blocks, are sequentially connected to a writing device slider by a rope. A cylinder with a sheet of paper on which the resulting curve is traced is connected with the input shaft of the crank-rocker mechanisms via a worm gearing. The power shaft is

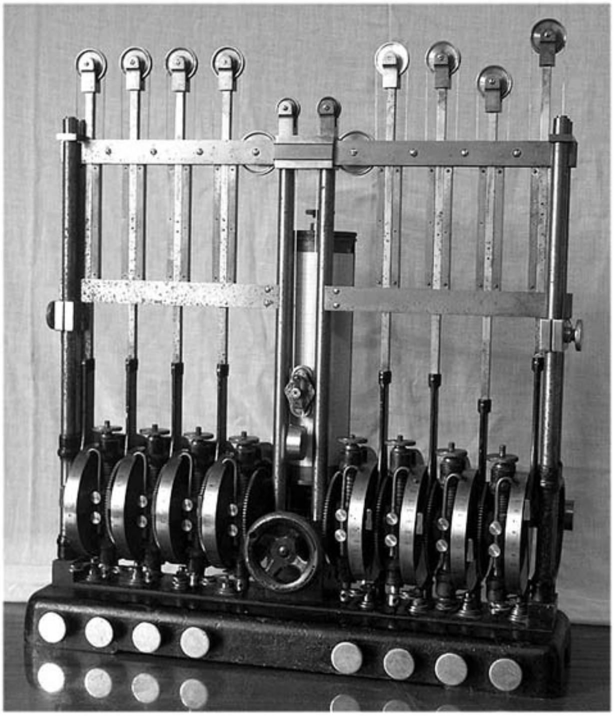

Fig. 2.15: The harmonizer designed by Smirnov

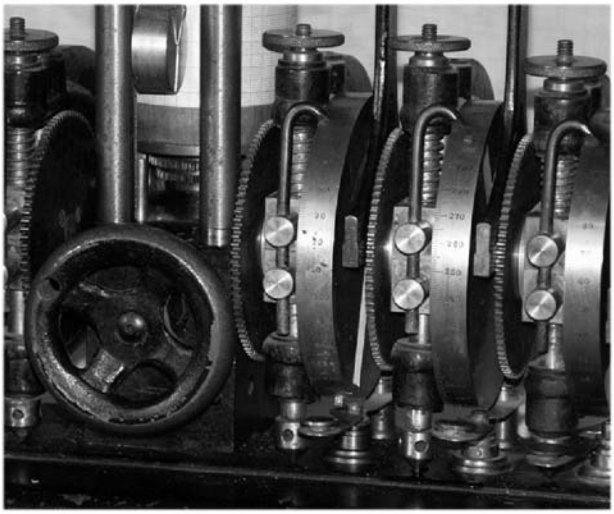

Fig. 2.16: The elements of the harmonizer's drivers

connected to the input shaft through gearings with gear ratios U = 1,2,3 and 4. There are two sine-mechanisms for each gear ratio: one of them provides an output sine curve, the other one – output cosine curve. Cranks of the sine-mechanisms are connected to the wheels of the gearings by screw mechanisms that permit to varying sine-curve amplitudes. After setting the amplitudes of the harmonics being summed, the shaft of the mechanism rotates and a pencil traces a sum curve on the coordinate paper sheet fixed on to the block. It takes no more than 20–30 minutes to set up the device and trace the curve.

2.5. Professor Leonid Reshetov's contribution

The major part of the collection of mechanisms is connected with the name of Leonid Reshetov. In 1930 after graduation from MMMI, Reshetov remained at the TMM department where he worked as an engineer and was simultaneously engaged in teaching activity. Because of his work he was closely connected with industry, especially with railway transportation. One of his first works was to research of theory of corrected evolvent cog-wheels. Reshetov made a big contribution to designing cam mechanisms. The results of this work were reflected in the monograph [29]. Reshetov was the a Honored Inventor of Russia, the author of more than 50 inventions. The majority were realized by industry. The big collection of kinematic pairs and statically definable connections, models of mechanisms of controllers, planetary mechanisms, hour calendars, cardans and many other devices were designed by him. In developing his ideas he almost always checked them on test mock-ups or models. All of them were created from his drawings and sketches. He personally made many models. He often made preliminary draft models using children's meccano sets.

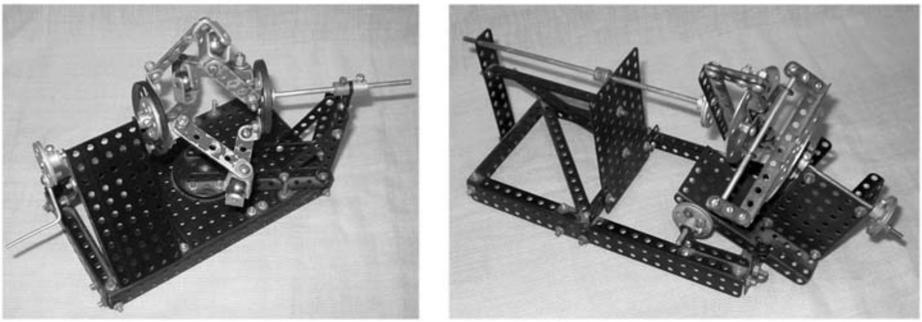

Fig. 2.17: The models of universal joints collected by L. Reshetov from the meccano sets

Examples of such models of universal joints are shown in Fig. 2.17. During all his time in the TMM department, Professor L. Reshetov was the curator of the collection of mechanisms. In 1974 Leonid Reshetov tried to create albums with descriptions of models. Only one album was completed. Work with the others, unfortunately, wasn't completed. In 1960–1970 the TMM course was considerably reduced. The number of employees of the department was also reduced, decreasing the number of premises used

by department. The collection of mechanisms had significant losses: many models were transferred to the Polytechnical museum, museum of BMSTU, and to departments of other institutes. Some of the models were replaced and left without supervision; many models were lost or destroyed. This trouble concerned not only BMSTU, but also many other organizations. In particular, the models of the Moscow University, Moscow Power University, Moscow Aviation University were lost. It was doubtless to the merit of L. Reshetov that the MSTU TMM department kept a considerable part of the collection of mechanisms.

2.6. Contribution of Professor Vladimir Gavrilenko's scientific school

Vladimir Gavrilenko, son of the first elective rector of IMTS A. Gavrilenko, headed the TMM department in 1962. This was the time when TMM was reduced, and its place was taken by new disciplines, basically connected with electronics and computer facilities. During this uneasy period, Gavrilenko managed to keep the basis of the collective of the department, to prepare a base for a course revival. As was already remarked, an incomplete a collection of models was kept. Revival of the department began in 1968. At this time new, young employees who now form basis of its collective were sent on faculty. During these years the TMM course was essentially modernized. Students began to perform two course works or two house tasks. The academic year project became more composite. New laboratory equipment ware was bought and new laboratory works were created. At this time, complete sets of models of the mechanisms, developed by SouzVuzPribor (special design offices which provide the educational process of universities of the USSR with models and devices) were bought. A scientific group under the direction of Gavrilenko whose problem was carrying out research and developmental works on crank-planetary and wave-tooth gearings, was organized in 1966 in the TMM department. On the basis of the theory of involute gearing, developed by Gavrilenko, special gear drives with internal involute gearing and wave-tooth gearings were projected in this group. Results of the work of this group found their place in a collection of mechanisms. Another source of updating of the collection during those years were the models created by the post-graduate students of the faculty resulting from scientific researches.

2.7. New times' problems and perspective views

Since 1978 and until now, BMSTU's TMM department has been headed by Academician of the Russian Academy of Sciences Professor Konstantin Frolov. For last decades the collection of mechanisms hasn't undergone many changes. There were neither significant receipts nor essential losses. In 1979 the educational laboratory and department have exchanged places, the laboratory has moved. Now the basic part of the collection of mechanisms is placed in the educational laboratory.

In 2004 the curator of the collection of mechanisms, Valentin Tarabarin, was appointed one of authors of this book. Under his management, ordering of the collection began, with the photographing and video shooting of models, and descriptions made. The historical part of the collection was allocated in separate section. Part of the missing models were found. In total, it has recorded more than 30 models, many of which concern rare models of 19th century. In the photo shown in Fig. 2.18, are shown some models after their extraction from base. In 2004–2005 contacts with the Sibley School

of Mechanics of Cornell University were established. This university possesses the largest collection of models of Reuleaux – Voigt and also a considerable historical library on applied mechanics. The curator of this collection Professor Francis Moon, heads the section on assemblies of models of mechanisms at the commission IFTOMM on TMM history. An Internet website devoted to the collections of Reuleaux mechanisms is located to the address: kmoddl.library.cornell.edu. On this site, a number of models from our collection is presented. In 2005 a symposium devoted to the 175th anniversary of BMSTU held a workshop on TMM history. More than 20 scientists from 15 countries of the world took part. Participants of the meeting were interested in the BMSTU collection of models of mechanisms and estimated it as a monument to the history of science and techniques on a world level.

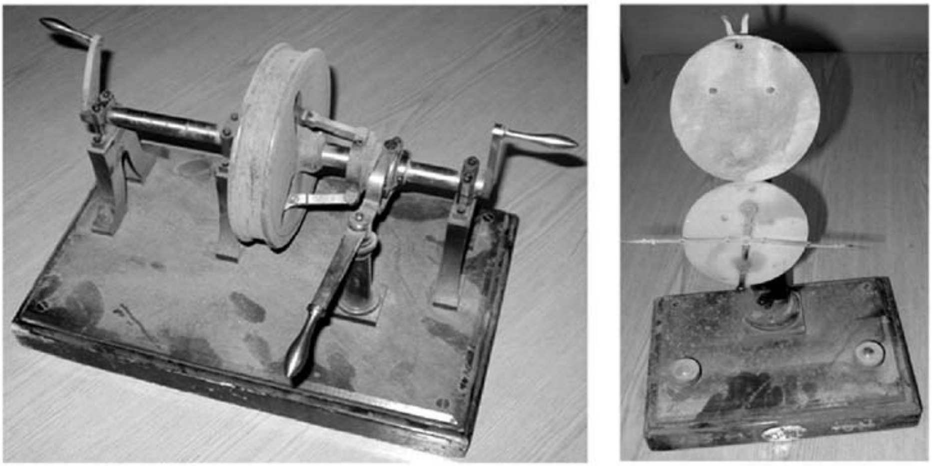

Fig. 2.18: The models of Reuleaux-Voigt taken from subfield

Now the collection numbers more than 600 models. Models are in various conditions. Most models require restoration and the carrying out of procedural work: cleaning, lubrication and painting. More complex problems emerge with models of 19th century because qualified restoration of many models is necessary. There are problems with the establishment of time and place of manufacture of some models. For tabulation of the electronic catalogue, it is necessary to describe and professionally photograph models, to lead to a qualitative video shooting of them. In the educational laboratory there is not enough room for the organization of a modern museum exposition, and there are no special cases for displaying exhibits. We hope that all these difficulties will be overcome and the collection of mechanisms will be presented with dignity in BMSTU.

2.8. Classification of mechanisms of the Bauman University collection

There was no comprehensive inventory of the collection of models made over the lifetime of the TMM department (that is, over 150 years). In the 1970s the arrangement of books of models began under the direction of Professor L. Reshetov. The books contained photographs of models and their brief descriptions. Teaching staff and postgraduates of the department were involved in the work. Only one of the books was

completed (Fig. 2.19). Photographs, partially completed schemes of mechanisms and descriptions were prepared for the other books, but the work remained unfinished.

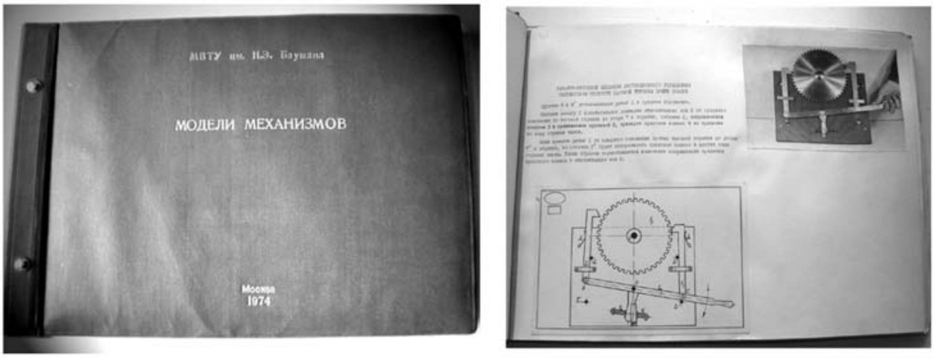

Fig. 2.19: An album with descriptions of models from the BMSTU collection and one of sheets of the album with a description of the mechanism of a regulator

Nowadays the majority of models of the collection have an enamelled plate with the model's symbolic notation engraved on it. The notation consists of a Roman alphabet letter and a number. Analysis of models of the collection allowed us to disclose the following correspondence between notation letter and mechanism type: *A* – kinematic pairs; *B* – linkages and gear-and-link mechanisms; *C* – mechanisms of cardan joints (universal joints); *D* – screw mechanisms and wedge mechanisms; *E* – cam mechanisms; *F* – friction mechanisms (clutches and couplings, braking devices, belt transmissions); *G* – non-round wheel gearings, counter mechanisms, reverse trundle transmissions; *H* – planetary trains and differentials; *I* – models of connecting profiles; *J* – toothings; *K* – screw, worm and spiroid gearings; *L* – intersecting axes gearings (bevel gearings); *M* – planar linkages; *N* – mechanisms of planetary trains and differentials; *O* – inertia governors; *P* – mechanisms of devices with pneumatic actuators; *Q* – straight-line-and-guide linkages; *R* – steam engine mechanisms, crankless mechanisms, mechanisms of hydraulic motors; *S* – simple gear mechanisms; *Z* – gear clutches. The authors did not succeeded in finding ground or description of the mechanism classification system in the available literature. Inquiry of senior members of the teaching staff of the department did not permit us to determine the authors of the classification either. Our research allowed us to ascertain the following. On the left of Fig. 2.20 photographs of three models of the collection from Mertsalov's book [17], which was published in 1916, are shown. Here one can see that models of Leonardo da Vinci's machine and two models of Chebyshev's straight-line mechanism have plates with engraved numbers "111", "3" and "22" fixed on them. Thus, there was a simple notation without any division into types used when the photographs of these models were taken.

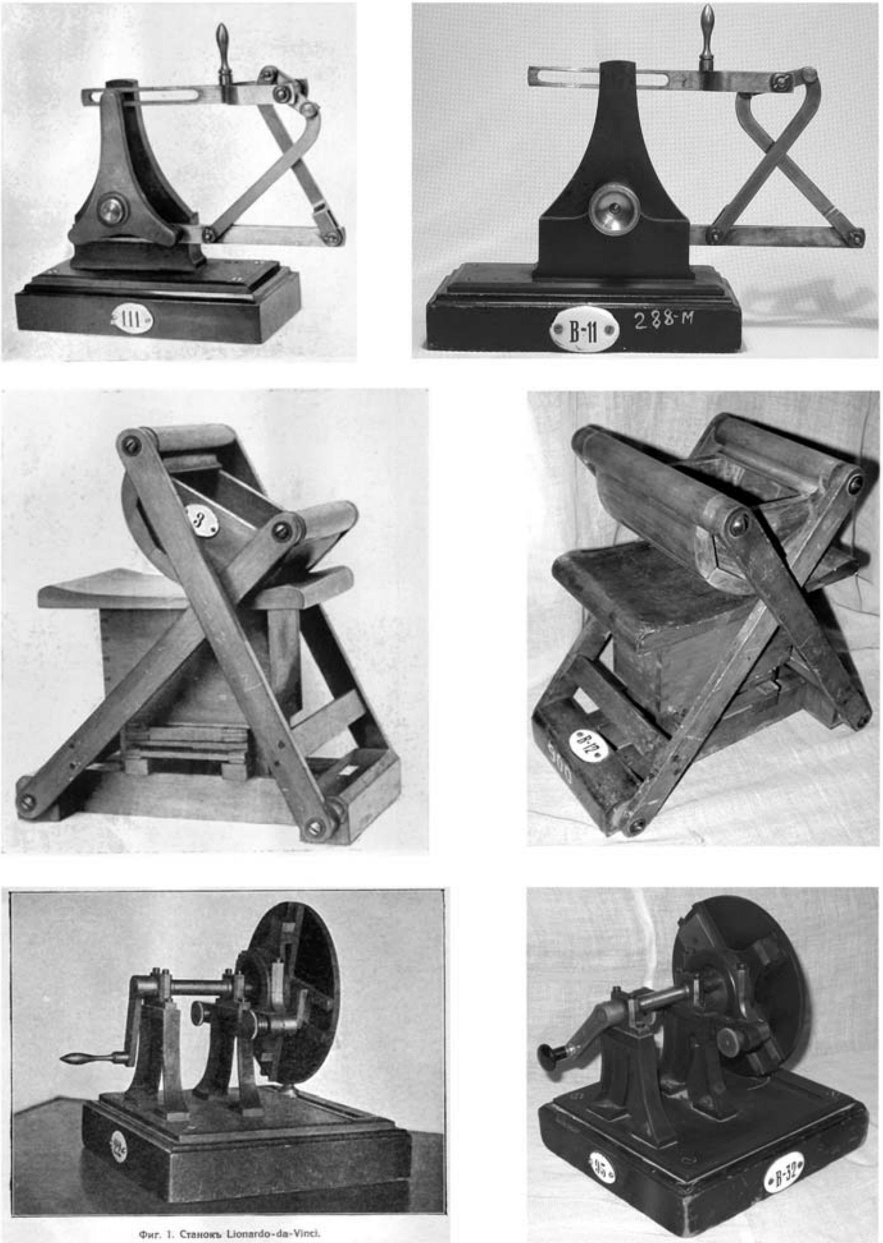

Fig. 2.20: Left, photos of models from Mertsalov’s book [15], and right, modern photos of the same models

On the right of Fig. 2.20 present-day photographs of the same models are shown. The models have plates with symbolic notations “B-12”, “B-11” and “B-32” there, the model of Leonardo da Vinci’s machine having two such plates: “95” and “B-32”. Therefore, between 1916 and 1960 the numeration of models was changed twice. First, Leonardo’s model had plate “22” replaced by plate “95”, then plate “B-32” was added. N. Mertsalov was head of the TMM department till 1929. Then the post was taken up by L. Smirnov. Engineer L. Reshetov began working at the department after graduating from the School (that time it was called MMMI) in 1930. In 1937 he left the department. When he returned in 1951 he became its head and headed the department till 1962. Since then and until his retirement he supervised the collection of mechanisms and perhaps he was the one who introduced the alpha-numerical classification of mechanism models. The fact that models developed by Reshetov in the 1930–1970s have the same symbolic notation also counts in favor of the fact. Section “B” appears to be the largest one. It includes various mechanisms: planar linkages, gear-and-link mechanisms, trundle clutches, straight-line-and-guide linkages, Leonardo’s machine. Sections “H” and “N” consist of types of mechanisms close to the those in section “B”. Thus, sometimes it is a problem to define what section the mechanism belongs to. For example, it is not understood why all typical planetary trains are attributed to section “H” and Lahire’s mechanism, to section “N. Similar problems occur with other mechanisms, too. Many mechanisms of the collection do not have classification numbers or inscriptions, part of the models have them damaged (unreadable) or do not have them at all. Therefore, much remains to be done concerning classification and systematization of models of the collection. Unfortunately, all known mechanism classification systems suffer from the same disadvantage.